IS 10922 (1984): Copper Foil for Use in the Manufacture of Copper-clad Base Material [LITD 5: Semiconductor and Other Electronic Components and Devices]

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Indian Standard

SPECIFICATION FOR COPPER FOIL FOR USE IN THE MANUFACTURE OF COPPER-CLAD BASE MATERIAL

(IEC Title : Metal-Clad Base Materials for Printed Circuits, Part 3 : Special Materials Used in Connection with Printed Circuits, Specification No. 2 : Specification for Copper Foil for Use in the Manufacture of Copper-Clad Base Materials)

Printed Circuits Sectional Committee, LTDC 17 [Ref : Doc : LTDC 17 (750)]

National Foreword

This Indian Standard, which is identical with Specification No. 2 of IEC Pub 249-3A (1976) 'Metal-clad base materials for printed circuits, Part 3 : Special materials used in connection with printed circuits, Specification No. 2 : Specification for copper foil for use in the manufacture of copper-clad base materials', issued by the International Electrotechnical Commission (IEC), was adopted by the Indian Standards Institution on the recommendation of the Printed Circuits Sectional Committee and approved by the Electronics and Telecommunication Division Council.

Cross References

In this Indian Standard, the following International Standards are referred to. The corresponding Indian Standards shall be read in their respective places :

International Standard	*Corresponding Indian Standard*
IEC Pub 249-1 Metal-clad base materials for printed circuits, Part 1 : Test methods	IS : 5921 (Part 1)-1983 Specification for metal-clad base materials for printed circuits for use in electronics and telecommunication equipment : Part 1 General requirements and tests (Technically equivalent)
IEC Pub 68-2-20C Third supplement, Test Ta : Second Part, Method for testing the solderability of printed wiring boards and metal-clad base laminates	IS : 9000 (Part XVIII/Sec 3)-1981 Basic environmental testing procedures for electronic and electrical items : Part XVIII Solderability test, Section 3 Solderability of printed boards and metal clad laminates (Technically equivalent)
IEC Pub 249-2 Metal-clad base materials for printed circuits, Part 2 : Specifications	IS : 5921 Specification for metal-clad base materials for printed circuits for use in electronics and telecommunication equipment (Relevant parts) (Technically equivalent)

Adopted 1 June 1984 | | Gr 5

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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1. Scope

This specification gives requirements for properties of copper foil intended for use in the manufacture of copper-clad laminated sheets and of copper-clad flexible materials, used for printed wiring.

This specification applies to copper foil supplied in rolls, but by agreement between purchaser and vendor, may be applied to foil produced in sheets.

2. Designation

Copper foil for the uses considered in this specification may be either of two types, as specified by the purchaser:

— Type A, electro-deposited copper foil (standard or high ductility);
— Type B, rolled copper foil (as rolled, lightly cold-rolled, or rolled and annealed).

3. Mass per unit area, and thickness

The primary measure of quantity of copper foil shall be the mass per unit area, together with applicable tolerances. Thicknesses of copper foil corresponding to specified values of unit mass, together with corresponding tolerances for thickness, shall be regarded as given for information only. The requirements apply to both Type A and Type B, with the exception that the first line of the table is held under consideration for Type B and applies only to Type A.

TABLE I

Requirements				*For information only*					
Nominal mass per unit area		Deviation in per cent of nominal mass		Nominal thickness		Thickness deviation			
						Class I		Class II	
g/m²	oz/ft²	Class I	Class II	μm	in	μm	in	μm	in
152	0.5	±10%	±5%	18	0.0007	±5	±0.0002	±2.5	±0.0001
230	0.75	±10%	±5%	25	0.0010	±5	±0.0002	±2.5	±0.0001
305	1	±10%	±5%	35	0.0014	±5	±0.0002	±2.5	±0.0001
610	2	±10%	±5%	70	0.0028	±8	±0.0003	±4.0	±0.000 15
915	3	±10%	±5%	105	0.0042	±10	±0.0004	±5.0	±0.0002

Mass per unit area shall be determined by test method 1 of this specification.

4. Chemical analysis

Type A copper foil shall have a minimum purity of 99.8% copper (with silver content regarded as copper), excluding any "as shipped" surface treatment.

AMENDMENT NO. 1 MAY 1987

TO

IS:10922-1984 SPECIFICATION FOR COPPER FOIL FOR USE IN THE MANUFACTURE OF COPPER-CLAD BASE MATERIAL

(Page 1, National Foreword) Add the following new paras after the first para of the National Foreword:

'This standard covers two types of copper foils as follows:

a) Type A, electro-deposited copper foil, and

b) Type B, rolled copper foil.

The use of Type A electro-deposited copper foil is recommended in the manufacture of copper clad base materials for printed circuits.

The standard covers both inch and metric dimensions but only metric dimensions have been adopted for Indian Standard.

The tolerance on width of copper foil over 1 200 mm shall be 3.0 mm in Table 3.

The temperature of solder in 8.1 shall be $260 \pm {}^{5}_{0}$°C.'

(LTDC 17)

Reprography Unit, BIS, New Delhi, India

Type B copper foil shall have a minimum purity of 99.9% copper (with silver content regarded as copper), excluding any "as shipped" surface treatment.

The copper content shall be calculated as prescribed in test method 2 of this specification. The chemical analysis shall be carried out after removal of any surface treatment or contamination (e.g. grease) from the surface of the specimen.

5. Electrical properties

For both Type A and Type B copper foil having a nominal mass per unit area of 152 g/m² (0.5 oz/ft²), the minimum conductivity shall be 93.70% of the International Annealed Copper Standard (IACS) at 20 °C (68 °F), equivalent to 0.163 59 Ωg/m² (= 1.840 · 10^{-6} Ωm in S.I. units).

For both Type A and Type B copper foil having a nominal mass per unit area equal to or greater than 305 g/m², (1 oz/ft²), the minimum conductivity shall be 96.16% of the International Annealed Copper Standard (IACS) at 20 °C (68 °F), equivalent to 0.159 40 Ωg/m² (= 1.793 · 10^{-6} Ωm in S.I. units).

The maximum resistance of copper foil, corrected to 20 °C (68 °F), when measured in accordance with the test method described in Sub-clause 2.1 of IEC Publication 249-1, Metal-clad Base Materials for Printed Circuits, Part 1, Test Methods, shall be as follows:

Mass per unit area	*Maximum resistance*
152 g/m² (0.5 oz/ft²)	7.0 mΩ
230 g/m² (0.75 oz/ft²)	5.5 mΩ
305 g/m² (1 oz/ft²)	3.5 mΩ
610 g/m² (2 oz/ft²)	1.75 mΩ
915 g/m² (3 oz/ft²)	1.17 mΩ

6. Tensile properties (requirements for either lengthwise or crosswise direction)

TABLE II

Mass per unit area		Minimum tensile strength		Minimum elongation percentage	
g/m²	oz/ft²	N/cm²	lbf/in²	Standard	High ductility
		Type A copper foil			
152	0.5	10 500	15 000	2	5
230	0.75	16 000	23 000	2.5	7.5
305	1.0	21 000	30 000	3	10
610	2.0	21 000	30 000	3	15
915	3.0	21 000	30 000	3	15
		Type B copper foil, as rolled			
152	0.5	35 000	50 000	0.5	
230	0.75	35 000	50 000	0.5	
305	1.0	35 000	50 000	0.5	
610	2.0	35 000	50 000	1	
915	3.0	35 000	50 000	1	
		Type B copper foil, lightly cold-rolled			
152	0.5	Not manufactured in this condition			
230	0.75	Not manufactured in this condition			
305	1.0	Not manufactured in this condition			
610	2.0	22 500	32 000	5	
915	3.0	22 500	32 000	5	
		Type B copper foil, rolled and annealed			
152	0.5	10 500	15 000	5	
230	0.75	12 000	17 000	5	
305	1.0	17 500	25 000	5	
610	2.0	17 500	25 000	10	
915	3.0	17 500	25 000	10	

Tensile strength and elongation shall be determined in accordance with test method 3.

7. Surface finish

One surface of both Type A or Type B copper foil shall have a maximum roughness of 0.4 μm (16 μin), arithmetic average, as determined with a surface finish-measuring instrument having a tracing probe with a tip radius of 12.5 μm, using a tracing force of 0.005 N and a cut-off of 0.75 mm (0.030 in). Measurements shall be made on each of three specimens from a given lot in the lengthwise direction, and on each of three specimens in the crosswise direction, and the six measurements averaged to determine compliance with the requirement.

Nodules on the rough side of Type A copper foil shall not exceed the following limits for elevation above the general plane of the copper foil surface:

Mass per unit area	*Maximum elevation*
152 g/m² (0.5 oz/ft²)	5 μm (0.0002 in)
230 g/m² (0.75 oz/ft²)	5 μm (0.0002 in)
305 g/m² (1 pz/ft²)	5 μm (0.0002 in)
610 g/m² (2 oz/ft²)	8 μm (0.0003 in)
915 g/m² (3 oz/ft²)	10 μm (0.0004 in)

Both sides of Type A and Type B copper foil shall be substantially free from wrinkles, dirt, oil, corrosion or corrosion products, salts, grease, finger-prints, or other blemishes which would adversely affect the quality of the copper-clad material to be made from the foil.

There shall be no scratches present on the smooth side of greater depth than 0.0035 mm (0.000 14 in).

Copper foil surfaces shall be free from regularly spaced and repeating patterns of pits and dents.

There shall be no inclusions greater than 0.0025 mm (0.0001 in) in the longest dimension.

Maximum size and frequency of pinholes and porosity of copper foil having a mass of less than 305 g/m² shall be established by agreement between purchaser and vendor. For foil of 152 g/m² mass, in the absence of an agreement between purchaser and vendor, the maximum limit of porosity shall be 30 points of penetration in an area of 300 mm × 300 mm (12 in × 12 in), when the specimen is tested according to test method 4 of this specification. The longest dimension of any pinhole shall be max. 0.05 mm (0.002 in).

For copper foil of 230 g/m², the following values are given for guidance: maximum limit of porosity: 15 points of penetration in an area of 300 mm × 300 mm (12 in × 12 in). Longest dimension of pinholes: 0.05 mm (0.002 in).

For copper foil equal to or greater than 305 g/m² (1 oz/ft²), the maximum limit of porosity shall be 8 points of penetration in an area of 300 mm × 300 mm (12 in × 12 in), when the specimen is tested according to test method 4 of this specification.

The area of any one or number of pinholes in an area of 0.5 m² (5.4 ft²) shall not exceed the area of a circle of diameter 0.125 mm (0.005 in).

8. Solderability

The solderability of the copper foil shall be tested in accordance with IEC Publication 68-2-20C, Third supplement, Test Ta: Second part, Method for Testing the Solderability of Printed Wiring Boards and Metal-clad Base Laminates, with the following supplementary specifications:

8.1 *Solder temperature*

The temperature of the solder shall be 235^{+5}_{-0} °C.

8.2 *Cleaning of the specimen*

8.2.1 *Copper foil without additional surface treatment (in accordance with Sub-clause 3.10.3.1 of IEC Publication 249-1C, Third supplement to Publication 249-1)*

The specimen shall be degreased by immersion in a neutral organic solvent at room temperature, dried, immersed

for 15 s in a solution of HCl (one part of HCl of density 1 180 kg/m³ and four parts water by volume), then rinsed in de-ionized water and dried in hot air.

8.2.2 *Copper foil with additional surface treatment*

The supplier of the foil shall specify the cleaning method.

8.3 *Specimen holder*

The specimen holder shall comply with Sub-clause 3.3 of IEC Publication 68-2-20C.

The copper foil specimen shall be mounted in a suitable way, e.g. wrapped around a piece of polytetrafluorethylene or other high-temperature resistant plastic material.

8.4 *Requirements*

— Wetting time: max. 2 s.
— Dewetting time: 5^{+1}_{0} s.
— Visual examination: the soldered surface shall comply with the illustrations given in IEC Publication 249-1C, Figure 11.

9. Surface treatment

The rough side of the copper foil should be free from dark strips in the longitudinal and transverse directions of the foil surface. The colour of the copper foil should be uniform in all directions.

If agreed upon between purchaser and vendor, the rough side of Type A copper foil, or one side of Type B copper foil may be given a chemical or electrochemical treatment to enhance adhesion of the copper foil to the required substrate.

If such a treatment has been applied, it shall be substantially uniform in colour and intensity over the entire area of the surface so treated, and shall be sufficiently adherent to withstand normal handling of the foil, including laminating. No more than traces of the treatment should be left on the etched surface of the substrate. No measurable difference in properties of the laminate caused by these traces should occur.

A certain disuniformity in colour of special treatments may be allowed provided that there is no difference in properties of the copper-clad laminate between the areas showing the different colours due to the treatment.

Because the purpose of surface treatment of copper foil is to enhance the adhesion of the foil to the substrate, the peel strength of the copper foil from the substrate shall meet the minimum requirements for the specified grade of copper-clad laminate according to IEC Publication 249-2, Part 2, Specifications, or currently in process of adoption as IEC standards.

10. Roll dimensions and tolerances

The width of the copper foil shall be as ordered. The following table gives the width tolerances for standard copper foil.

TABLE III

Width	Tolerance
From 50 mm to 300 mm (2 in to 11.8 in) inclusive	0.4 mm (0.016 in)
Over 300 mm to 600 mm (11.8 in to 23.6 in) inclusive	0.8 mm (0.032 in)
Over 600 mm to 1 200 mm (23.6 in to 47.2 in) inclusive	1.6 mm (0.063 in)

The length of the roll of foil shall be as ordered, with a tolerance of 10%.

In any length of roll, there shall be no more than three splices and each of these shall be plainly indicated by a durable marker which extends approximately 5 mm (0.25 in) beyond the end of the roll.

Any holes larger than allowable pinholes shall be indicated either by a flag or by the removal of the section containing the hole, with the two parts properly spliced and flagged.

Rolls shall be evenly wound on cores of the size and material agreed upon between purchaser and vendor. Telescoping may not exceed 12 mm (0.5 in) from the core to the outer layer of a roll.

11. Packaging

Rolls shall be individually wrapped and sealed in a waterproof material, so that the properties remain within the given requirements for a period of 90 days after shipment.

Depending on the size and mass of rolls being supplied on an order, rolls may be enclosed individually, or several rolls together, in durable cases. Unless otherwise agreed upon by purchaser and vendor, the maximum gross mass of any case or package shall be 250 kg (550 lb).

All rolls of copper foil in a single package or case shall be of the same type, mass per unit area, class of mass tolerance, class of ductility or degree of annealing and type of surface treatment.

Each package or case shall be marked with the following information:

— type of copper foil;
— mass per unit area;
— class of mass tolerance;
— ductility class (or degree of annealing if Type B);
— net mass of foil; and
— type of treatment.

Individual packages within a case shall be marked with the approximate length (to within $\pm$ 1 m or 1 yd of true length), and this data shall also be marked on the outer packaging case if only one roll is enclosed.

Other marking, relative to the manufacturer's lot number, the purchaser's order number, the date shipped or similar commercial information, shall be as agreed upon by purchaser and vendor.

APPENDIX

SAMPLING AND METHODS OF TESTS

Sampling

From every 10 rolls in a lot, but from not less than 1 roll, a length of approximately 2 m (2 yd) or a minimum of approximately 2 m^2 (2 yd^2) shall be cut, with the free end of the sample marked for future identification. Specimens for all tests shall be obtained from these sample lengths, from that part of the sample farthest from the free end.

Test method 1 — Mass per unit area

Specimens

A total of three specimens shall be cut from the sample length, one specimen adjacent to the centre line and each of the other two specimens adjacent to each edge. The specimens shall be cut oversize sufficiently to permit accurate final cutting of either circular disks of 113 ± 0.25 mm (4.44 ± 0.01 in) diameter or squares of 100 ± 0.25 mm (3.94 ± 0.01 in) side length, the corresponding area being 100 cm^2 (15.5 in^2).

Procedure

Each of the three specimens comprising a set shall be weighed on a balance having a precision of 10 mg, and the mass recorded to the nearest 10 mg. The average mass of the three specimens shall be computed and shall fall within the range given below:

TABLE IV

Nominal mass per unit area		Allowable mass in grams	
g/m^2	oz/ft^2	Class I	Class II
152	0.5	1.37 to 1.67	1.44 to 1.60
230	0.75	2.06 to 2.51	2.17 to 2.41
305	1.0	2.75 to 3.35	2.90 to 3.20
610	2.0	5.49 to 6.71	5.80 to 6.40
915	3.0	8.23 to 10.07	8.69 to 9.61

Test method 2 — Chemical analysis

Special apparatus

Source of direct current capable of delivering at least 1 A and having suitable rheostats and meters to control and measure the current with an accuracy of 5 mA.

Cathode

The cathode shall be formed from platinum wire of approximately 0.21 mm (0.0085 in) diameter in the form of a mesh or cloth having approximately 20 strands per centimetre (50 strands per inch).

The wire mesh shall be fashioned into a cylinder approximately 30 mm in diameter and 50 mm long, with the wire mesh doubled back on itself for a width of about 3 mm to strengthen the cylinder (total width of wire mesh required is approximately 56 mm for a length equal to the circumference of a 30 mm circle).

The connecting electrode shall be made from a platinum alloy (platinum with iridium, rhodium or ruthenium) wire approximately 1.3 mm in diameter and approximately 130 mm long. It shall be flattened for a length of 50 mm from one end, and this flat end welded to the entire height of the wire mesh cylinder, parallel to the axis of the cylinder. The area of this cathode will be approximately 135 cm^2, excluding the projecting portion of the connecting stem.

Anode

The anode shall be formed from platinum wire at least 1 mm in diameter, fashioned into a helix of 7 turns, a diameter of approximately 12 mm and a length of approximately 50 mm, with the remainder of the wire extending straight and parallel to the axis of the helix, so that the overall length of helix plus extension lead is approximately 130 mm.

Reagents

Sulphuric acid-nitric acid mixture, prepared by slowly adding, with stirring, 300 ml of concentrated sulphuric acid to 750 ml of distilled water, then cooling the mixture to room temperature and adding 210 ml of concentrated nitric acid. Distilled water and 95% alcohol shall be available for rinsing the plated cathode.

Procedure

Mark or otherwise identify a 5 g weight, and with it, weigh a quantity of the copper foil (which has been degreased by washing with acetone followed by air-drying) of a mass of 5.0050 g to 5.0070 g

Place the sample in a tall-form 200 ml or 300 ml lipless beaker. Add 42 ml of the sulphuric acid-nitric acid mixture and allow to stand until the reaction has nearly ceased. Then heat the solution at a temperature of 80 °C to 90 °C in a steam bath until dissolution is complete and all nitrogen oxide fumes have been expelled.

The beaker should be covered with a cover glass during this heating and when dissolution is complete, the sides of the beaker and the cover glass shall be rinsed in the beaker with distilled water

The cathode shall be weighed together with the marked 5 g weight, and the mass recorded to the nearest 0.1 mg The mass of the cathode alone is obtained by subtracting 5 g from the observed mass. Now the anode and cathode shall be immersed in the beaker of solution, which shall be covered with a pair of split cover glasses placed with the splits at right angles.

Electrolyze the solution at a current density of approximately 0.006 A/cm^2 until the solution becomes colourless (approximately 16 h). When the solution has become colourless, reduce the current to about 0.003 A/cm^2 and rinse down the cover glasses, electrode stems and the sides of the beaker. Continue the electrolysis until no more copper will be plated on a fresh surface of the electrode stem when the electrolyte level is raised slightly.

Without interrupting the current, siphon off the electrolyte while at the same time adding distilled water to the beaker to maintain the level of liquid. Quickly remove the cathode, while continuing to rinse with distilled water, rinse further with distilled water, then dip in two successive beakers of alcohol. Dry the cathode at 110 °C for 3 min to 5 min and allow to cool.

Weigh the plated cathode again, using the same set of weights as were used for the bare cathode, but omitting the 5 g weight with the cathode. Determine the mass of copper plated as the difference in mass of the plated cathode and the unplated cathode, and calculate the purity of the copper foil from the relationship:

$$\text{percentage copper} = 100 \times \frac{\text{mass of deposited copper}}{\text{mass of foil specimen}}$$

The determination shall be made in duplicate, and the two determinations shall agree within 0.015% copper, or be repeated.

For relatively low purity copper (of the order of 99.4%), the precision of analysis may be improved by following the procedure above to the point of washing the plated cathode, then placing the plated cathode in a 300 ml lipless

beaker covered with a cover glass perforated to permit the electrode stem to project, dissolving the plated deposit again with 42 ml of the sulphuric acid-nitric acid mixture together with enough water to cover the plated portion of the cathode.

Dissolution is completed by heating the solution of the steam bath as before, then repeating the electrolysis as before.

Test method 3 — Tensile properties of copper foil

Special apparatus

A precision testing machine, preferably equipped with a recording load-deflection chart. Smooth-surfaced specimen grips aligned to provide uniform contact with the full area of the specimen gripped. A specimen cutter comprising a double-blade shear, having the two blades parallel and separated by a distance of 15 ± 0.25 mm (0.6 ± 0.010 in), operating simultaneously to cut a strip of definite width in one cutting operation.

If the elongation is to be determined from a recording of the load-deformation curve, the separation of the cross head may be taken to be the same as the elongation of the total specimen length. If no recorder is available, a 50 mm (2 in) gauge length shall be marked by inscribing two parallel lines across the mid-section of the specimen at the opposite ends of an accurate template, making the marks either with a soft-point marking pen, or with a stylus having a point rounded to a 1 mm radius, with the inscribed marks extending no closer than 3 mm (0.125 in) to either edge of the specimen.

Specimens

Specimens shall be strips approximately 230 mm (9 in) long and 15 ± 0.25 mm (0.6 ± 0.010 in) wide. They are preferably cut from the same sample length from which the specimens for test method 1 were obtained. The thickness of the specimens shall be calculated from the mass of the specimens obtained as the average mass of four identical-size specimens, divided by the product of the area and the density. The area shall be determined by accurate measurement of the length and the width of the specimens, and the density shall be taken as 8.9 g/cm^3 when the area is determined in square centimetres, or 146 g/in^3 when the area is determined in square inches.

Procedure

Four specimens shall be tested from each sample of copper foil in the lot. The specimens shall be inserted in the grips of the testing machine so that a length of approximately 125 mm (5 in) is held between the grips, and this length shall then be measured to the nearest 0.1 mm (0.04 in).

The rate of strain during the tensile test shall be approximately 50 mm (2 in) per minute.

The breaking force at failure shall be recorded to the nearest 0.5 N (0.1 lbf).

The ultimate tensile strength shall be calculated in the usual way, by dividing the breaking force by the cross-section of the test specimen in the no-load condition, using the measured width of the test specimen and the thickness calculated from its mass, area and density.

Alternatively, the breaking force is divided by the width of the specimen to obtain the value in newtons per centimetre width.

The elongation shall be reported as a percentage of the initial length between the reference points.

The average ultimate tensile strength and the average elongation of the four specimens shall be computed for comparison with the minimum requirement of the specification.

Test method 4 — Dye penetration test for porosity

Penetrant

Prepare a solution of an oil soluble red dye in toluene, with a concentration of 1 g per litre. Filter if necessary to remove any undissolved particles

Specimen

A specimen shall be cut 300 mm (12 in) long by the width of the roll of foil.

Procedure

Lay the foil on a sheet of absorbent paper under a hood or on a well-ventilated work surface with the smooth side up Coat the entire surface of the foil with the dye solution applied with a brush or roller at ordinary room temperature.

After 5 min, turn the foil over and count the number of dye spots visible on the reverse side of the foil in any area 300 mm 300 mm (12 in · 12 in).